GRAPHS SHOWING TCE TRENDS IN GRENADA MFG WELLS

The figures in this attachment show TCE trends observed in Monitoring wells at the Grenada MFG site versus time created using a method developed by EPA (Wilson, 2011). The calculation of the regression line through the sample data, lines depicting the 1st and 2nd Confidence Intervals (CI), interim goals and final goals were performed using the methods described by Wilson (2008, 2011) without deviation.

The graphs were enhanced with two additional features:

First, the Final Cleanup Goal is depicted as a horizontal line at the value of the EPA Maximum Contaminant Level (MCL) for the Contaminant of Concern rather than as a single point as shown by Wilson.

Second, a series of Site-wide Interim Cleanup Goals are plotted as dots at 5-year intervals on all the figures. These dots are site-wide goals and are not based on the performance in any specific well at the site. These dots are for reference only and have exactly the same values on all figures even though they may appear to be different because the Y-axis changes from figure to figure. The X-Axis on each figure is 100 years long.

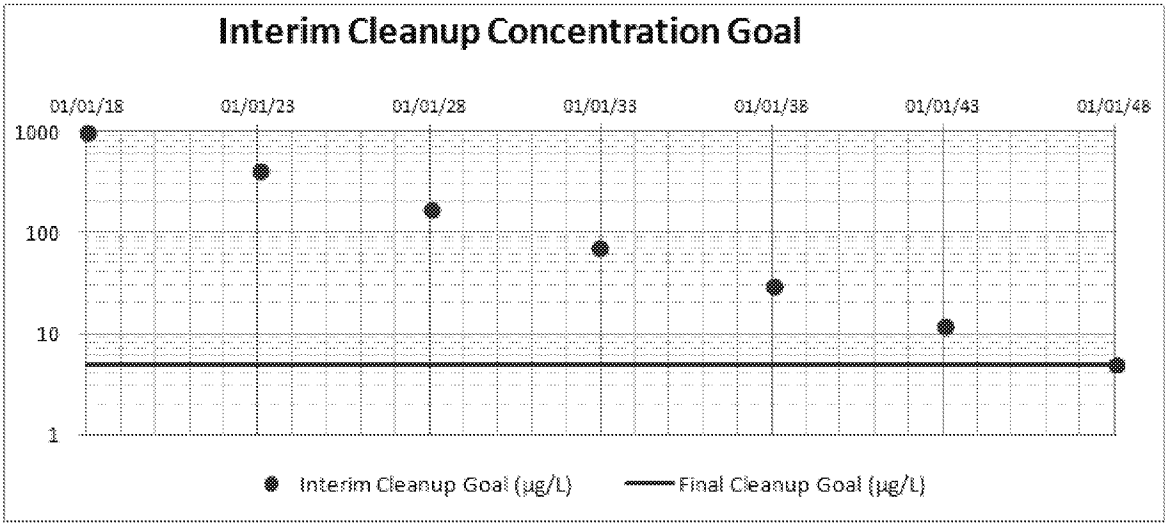
The Site-wide Interim Goals were calculated every 5 years using the following assumptions:

1. A reasonable timeframe for cleanup is assumed to be 30 years.
2. Target Cleanup Start date is January 1, 2018.
3. Cleanup Date is December 31, 2047. The Target Cleanup Goal is the year 2048.
4. The typical site-wide starting contaminant concentration assumed for planning purposes is 1,000 µg/L of TCE. Actual TCE concentrations in specific monitoring wells may be greater or are less than this assumed Site-wide starting concentration.
5. The Target Cleanup Concentration is the MCL for TCE = 5 µg/L.
6. Interim Cleanup Goals are calculated at 5-year intervals as benchmarks marking desired progress toward cleanup. These Interim Goals are shown for reference only and have no impact on the linear regression or confidence interval calculations.

The Site-wide Cleanup Goals calculated for this evaluation are shown below:

Review #	Site-wide Cleanup Goals			1/1/2018 Graph Start Date
0	Co	=	1,000	1/1/2018 The interim goal at the end of the review cycle # 00 in year 0
1	C_{i1}	=	414	1/1/2023 The interim goal at the end of the review cycle # 01 in year 5
2	C_{i2}	=	171	1/1/2028 The interim goal at the end of the review cycle # 02 in year 10
3	C_{i3}	=	71	12/31/2032 The interim goal at the end of the review cycle # 03 in year 15
4	C_{i4}	=	29	1/1/2038 The interim goal at the end of the review cycle # 04 in year 20
5	C_{i5}	=	12	1/1/2043 The interim goal at the end of the review cycle # 05 in year 25
6	C_{i6}	=	5	1/1/2048 The interim goal at the end of the review cycle # 06 in year 30

In graphical form, these interim goals and the MCL for the contaminant will appear on all figures in this section as shown below.



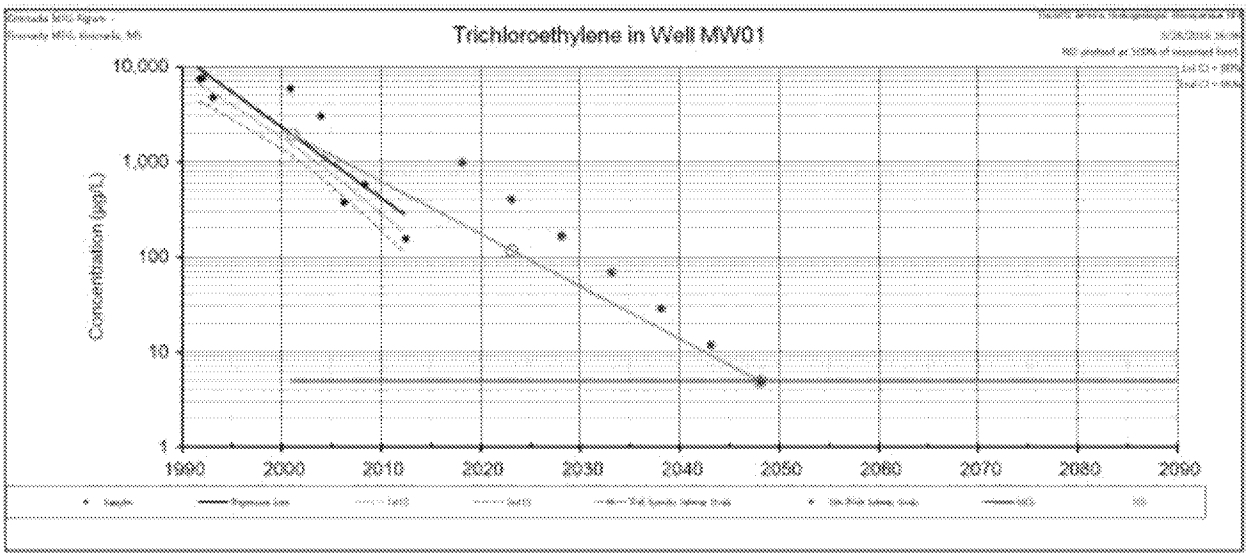
Again, the MCL is shown by the horizontal line. The Site-Wide Interim Goals shown by the dots will be the same on all graphs and are included only to facilitate comparisons from one well to another.

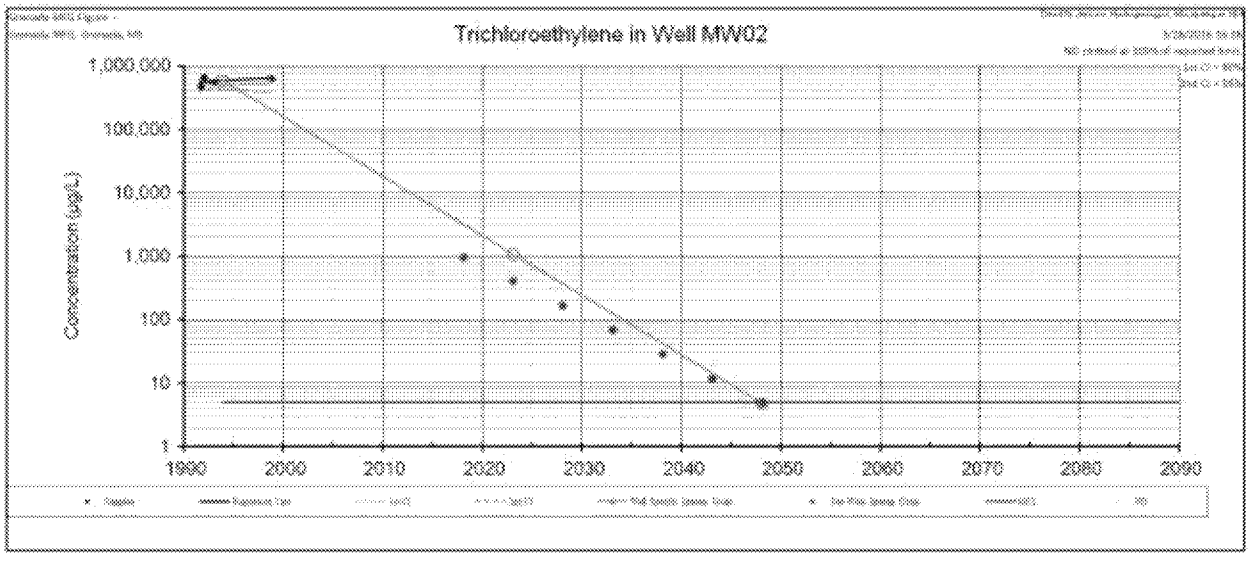
The figures below show TCE concentrations versus time all monitoring wells at the Grenada MFG site which have sampled enough times for this analysis. Well MW08 is an example of a well which is on track to be clean by the Target Cleanup Date, the year 2048, while MW04 is an example of a well making no progress toward cleanup. If current trends continue, other wells are expected to be clean before or after the Target Cleanup Date as shown on the following figures and listed in Table 1.

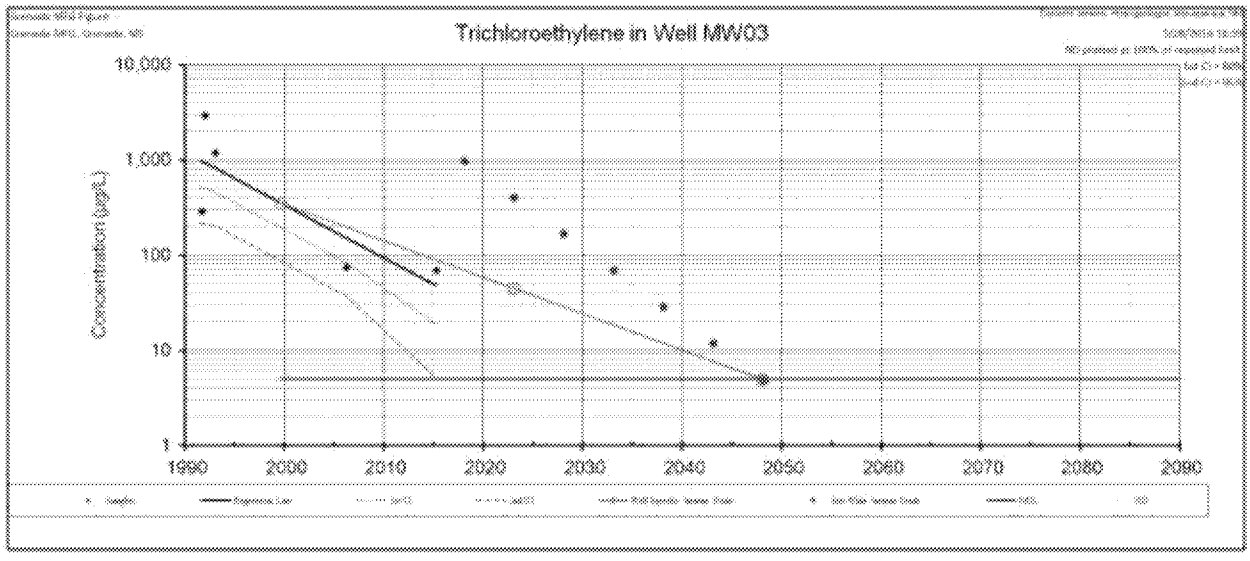
Areas near wells which cannot be shown to be on track to achieve cleanup by the Target Cleanup Date are areas which will be targeted for aggressive remedial measures described elsewhere in this document. An example of this decision process is described by Jenkins, 2012.

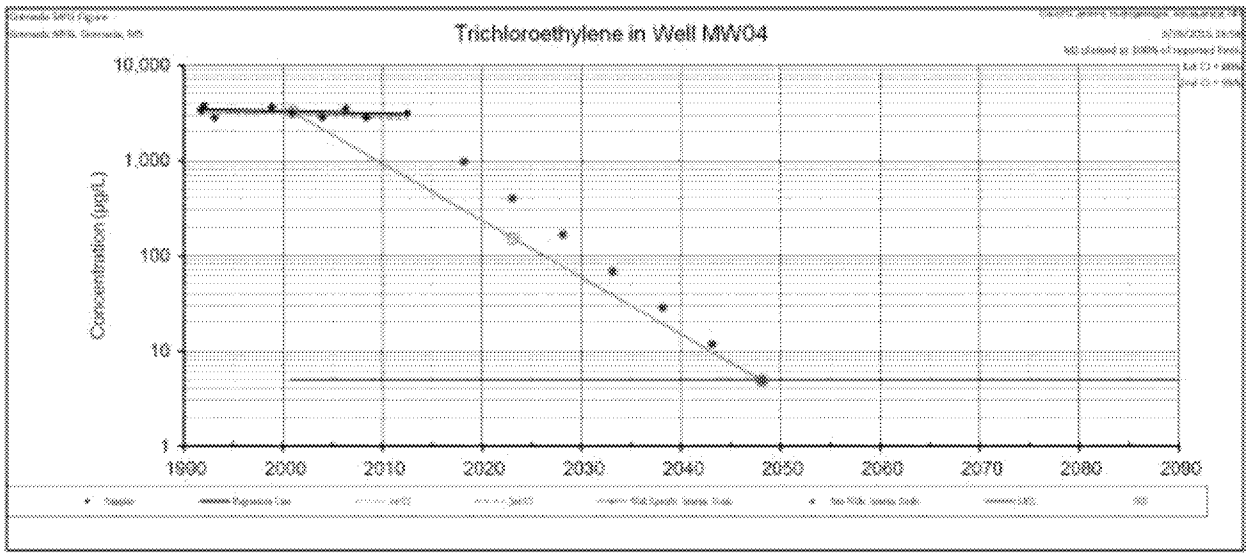
Some additional information regarding each of the figures presented below is presented in Table 9 of this report. Among other things, Table 9 shows that 25 years after investigations began at this site, TCE concentrations are increasing in 53 percent of the monitoring wells at the site which have a sufficient number of samples for trend evaluation. The plume of contaminated ground water is not stable and contaminant migration is not under control.

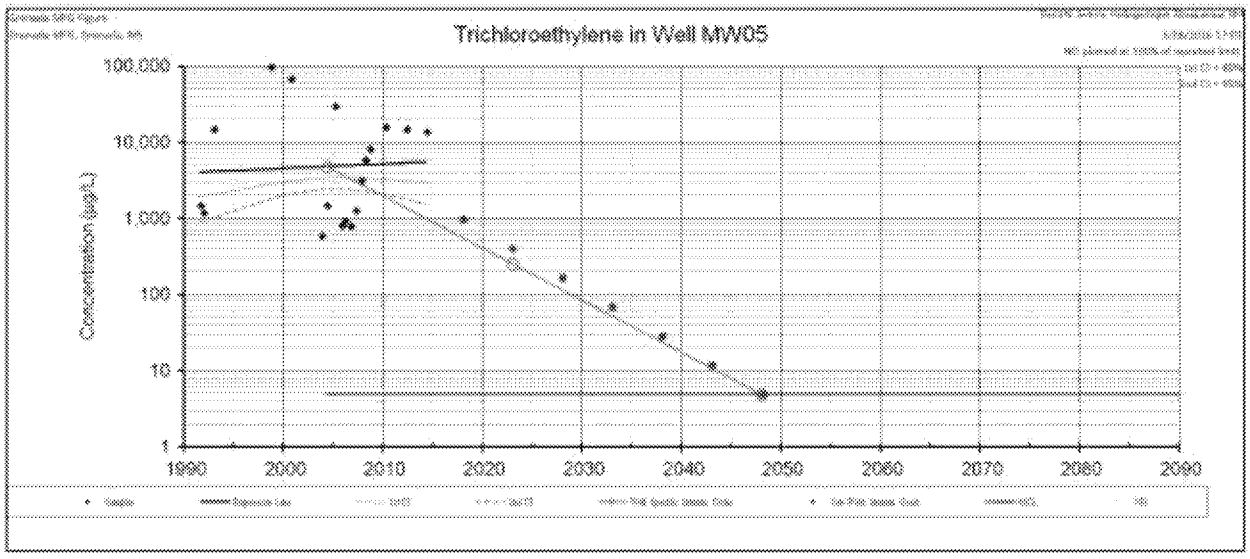
Please note that the Permeable Reactive Barrier was installed during the last quarter of 2004 and the 1st quarter of 2005. This installation would generally plot at the beginning of 2005 on the graphs shown below. TCE trends in wells near the PRB were affected by this installation and the effect can be seen in some of the graphs.

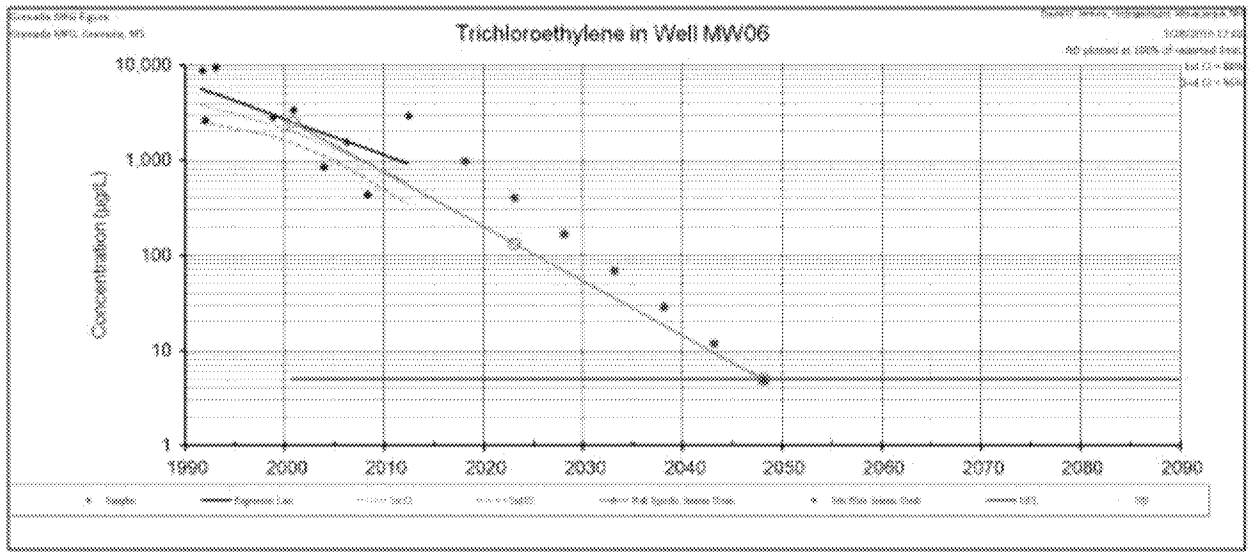

Trichloroethylene in Well MW01
Concentration (µg/L)
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

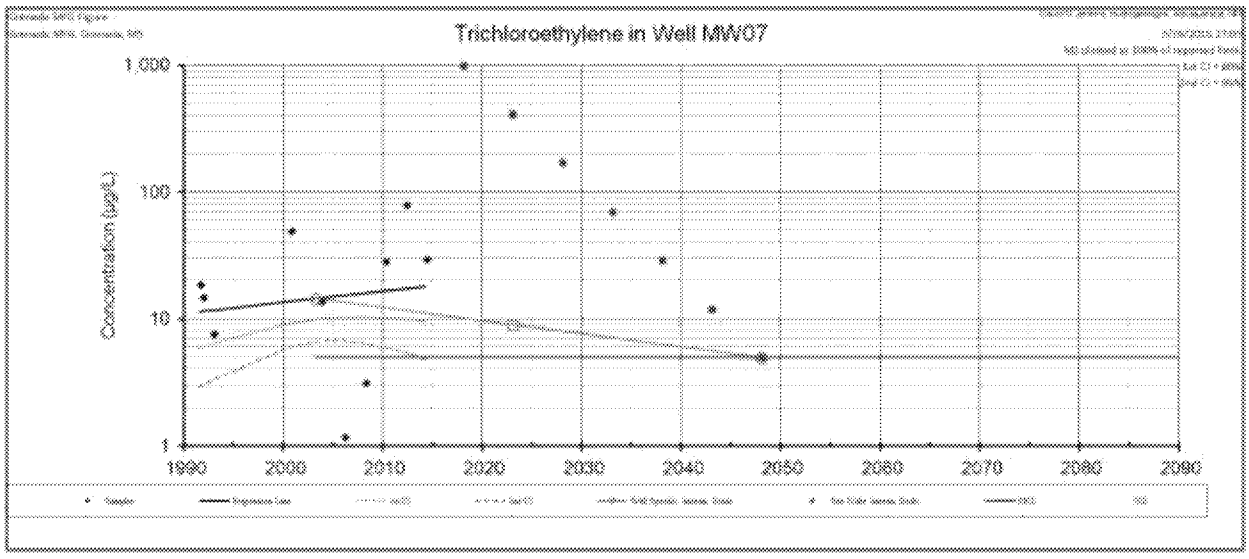

Trichloroethylene in Well MW02
Concentration (µg/L)
1,000,000
100,000
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

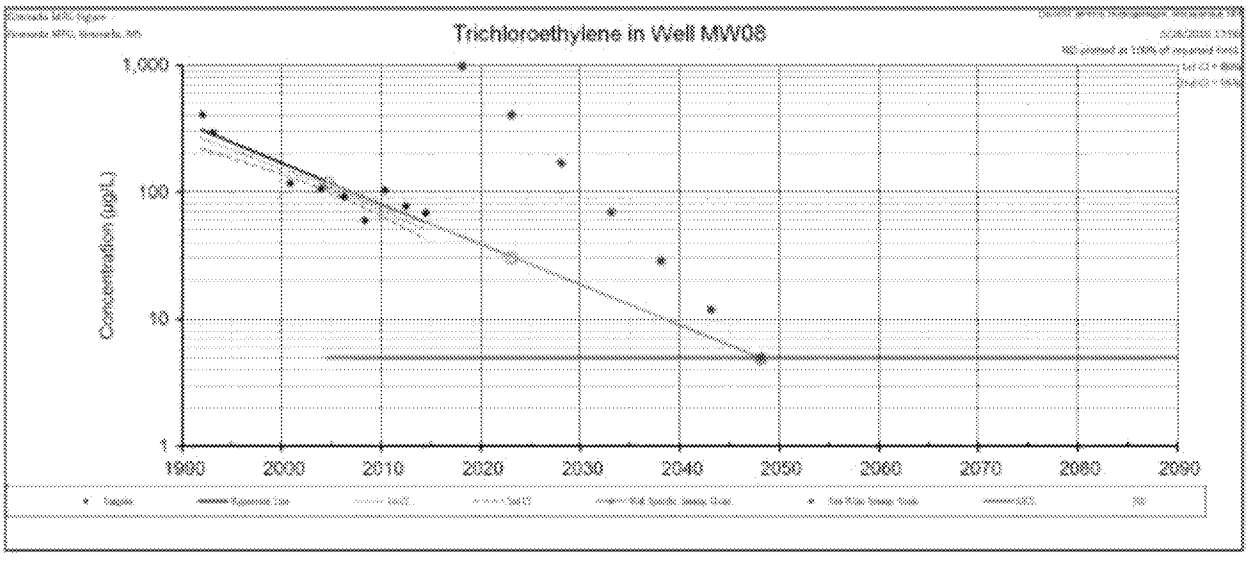

Trichloroethylene in Well MW03
Concentration (µg/L)
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

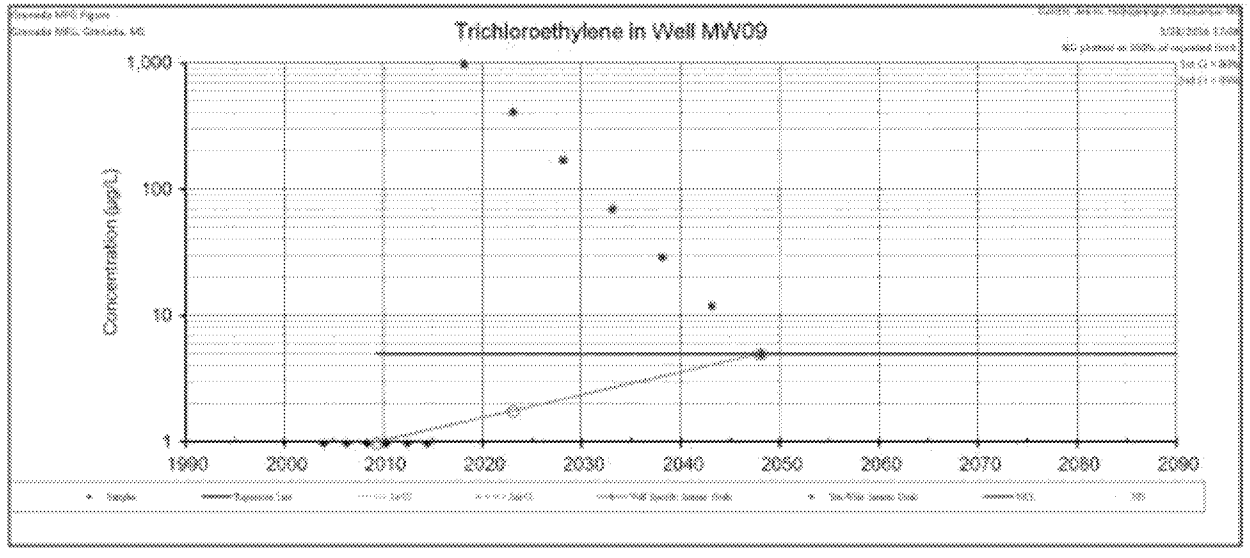

Trichloroethylene in Well MW04
Concentration (ppb)
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

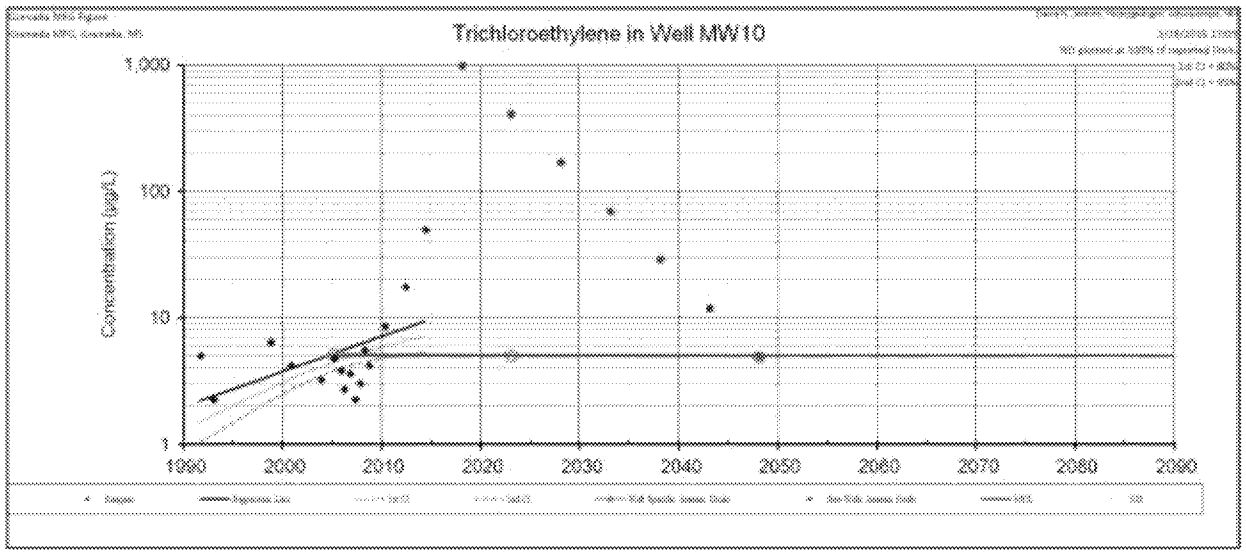

Trichloroethylene in Well MW05
Concentration (ppb)
100,000
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

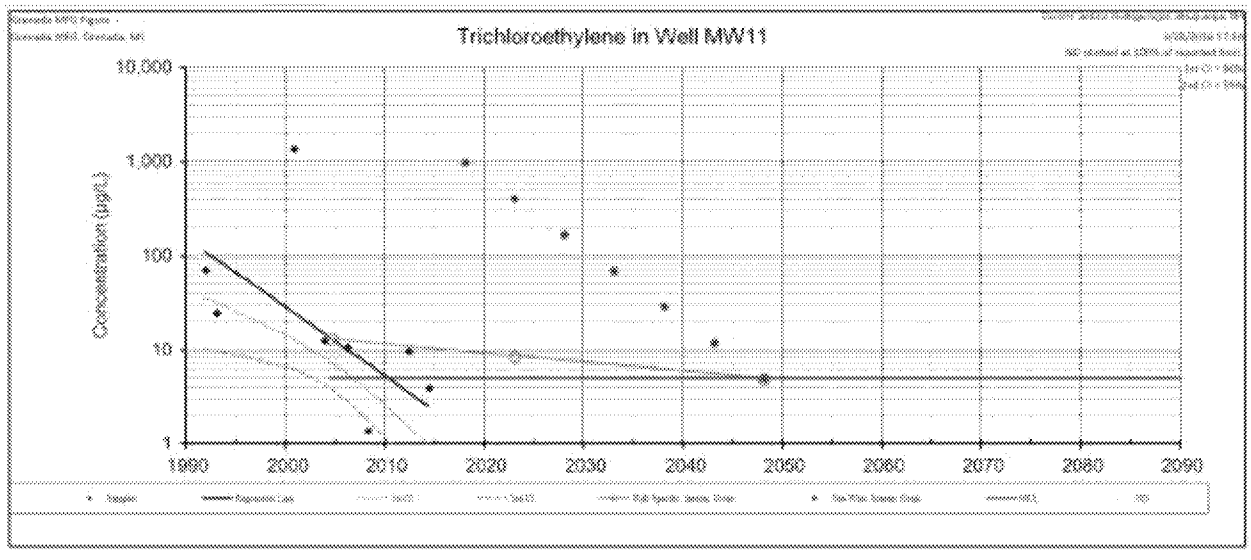

Trichloroethylene in Well MW06
Concentration (ppb)
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

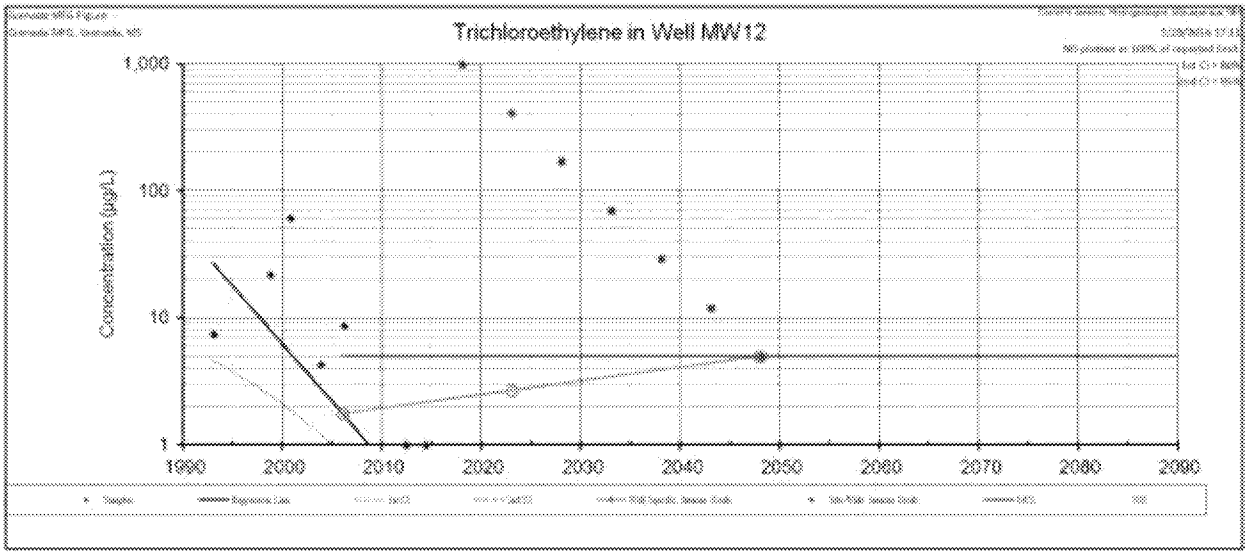

Trichloroethylene in Well MW07
Concentration (µg/L)
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

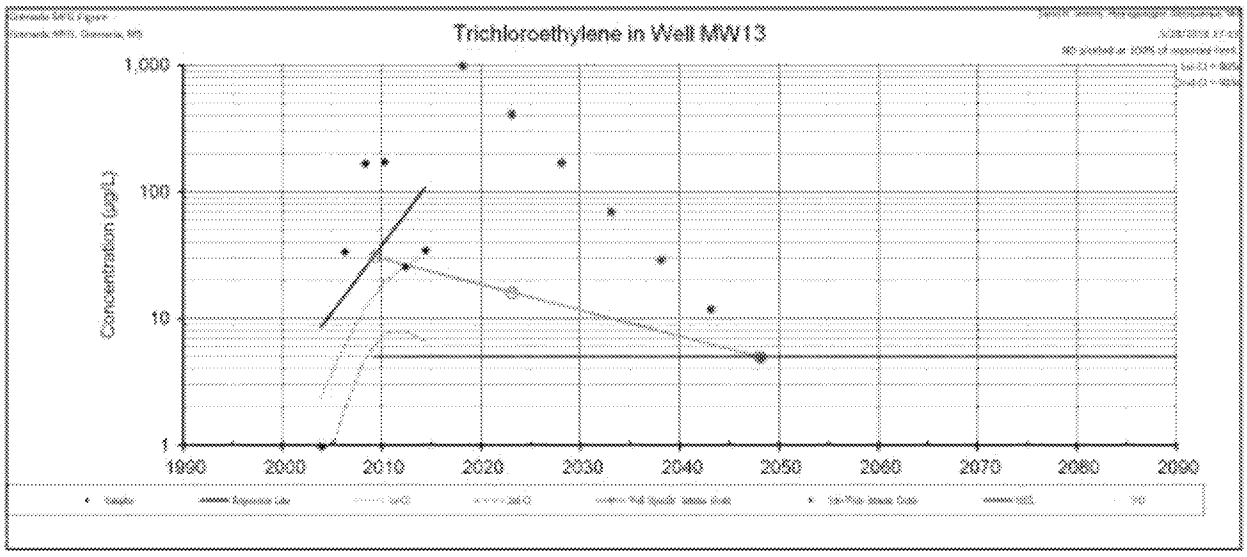

Trichloroethylene in Well MW08
Concentration (µg/L)
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

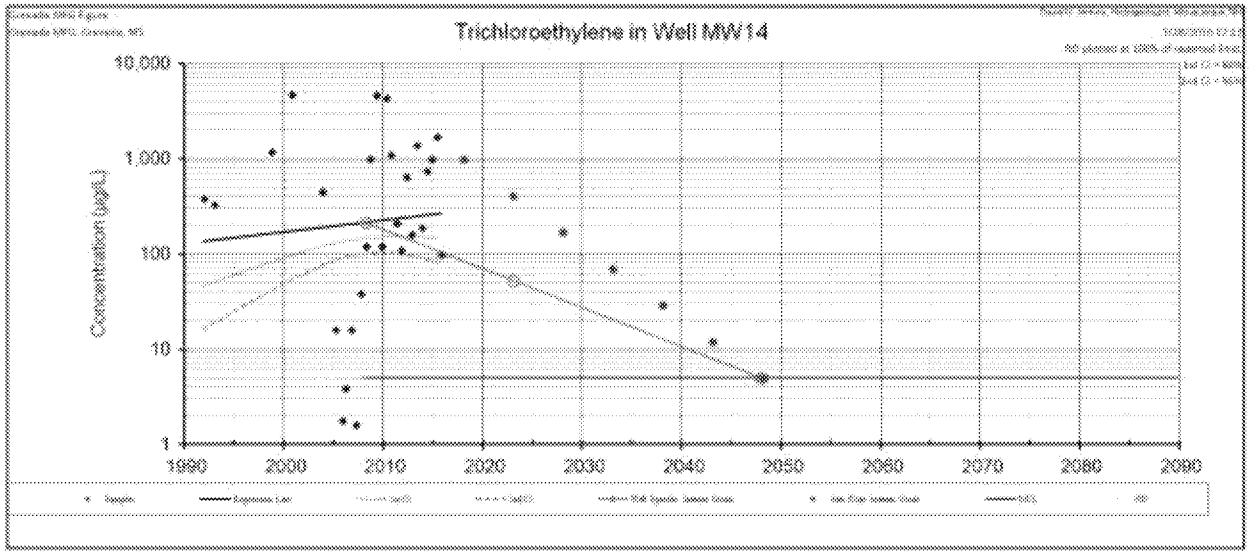

Trichloroethylene in Well MW09
Concentration (µg/L)
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

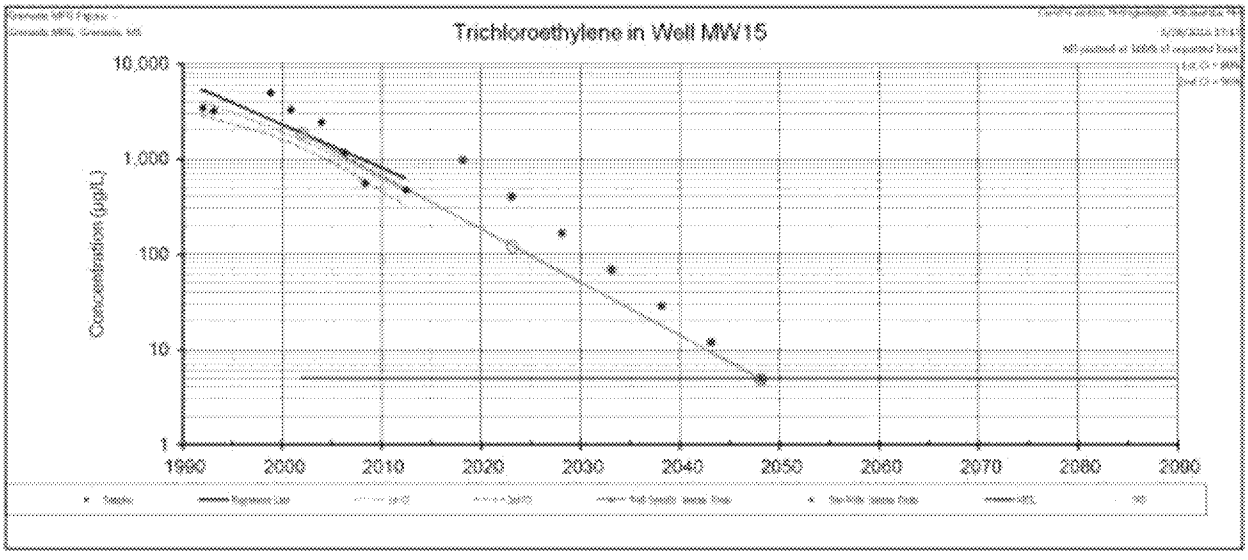

Trichloroethylene in Well MW10
Concentration (ug/L)
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

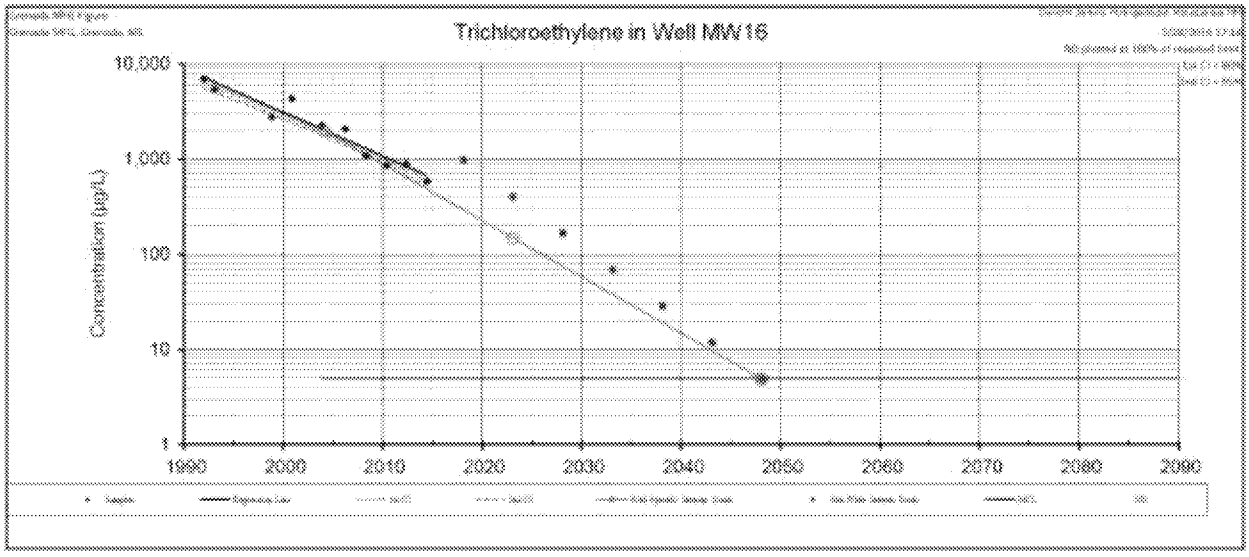

Trichloroethylene in Well MW11
Concentration (ug/L)
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

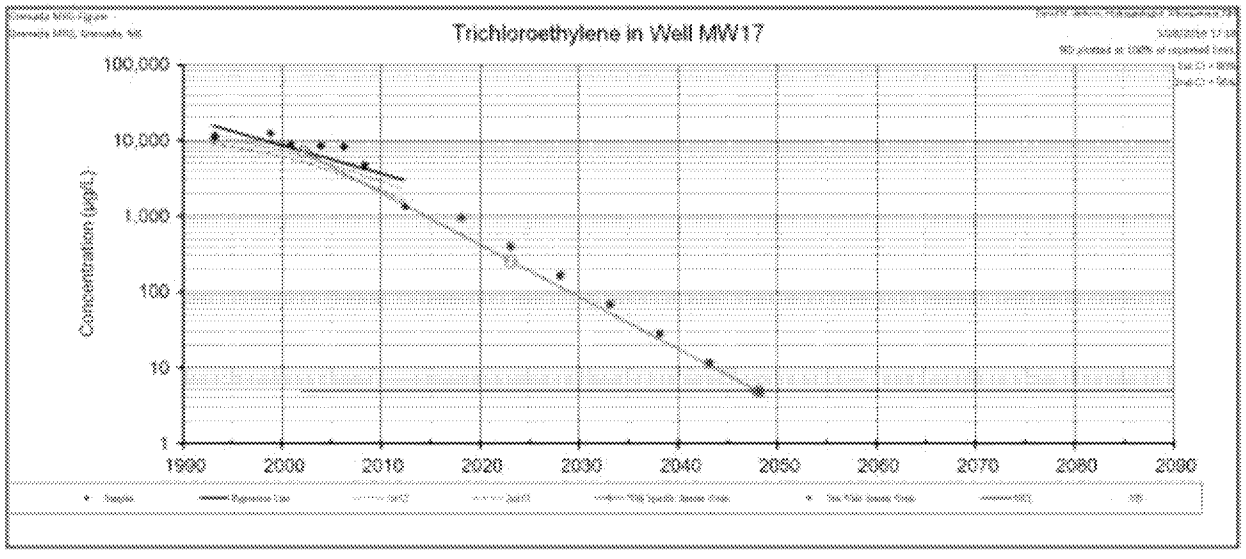

Trichloroethylene in Well MW12
Concentration (ug/L)
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

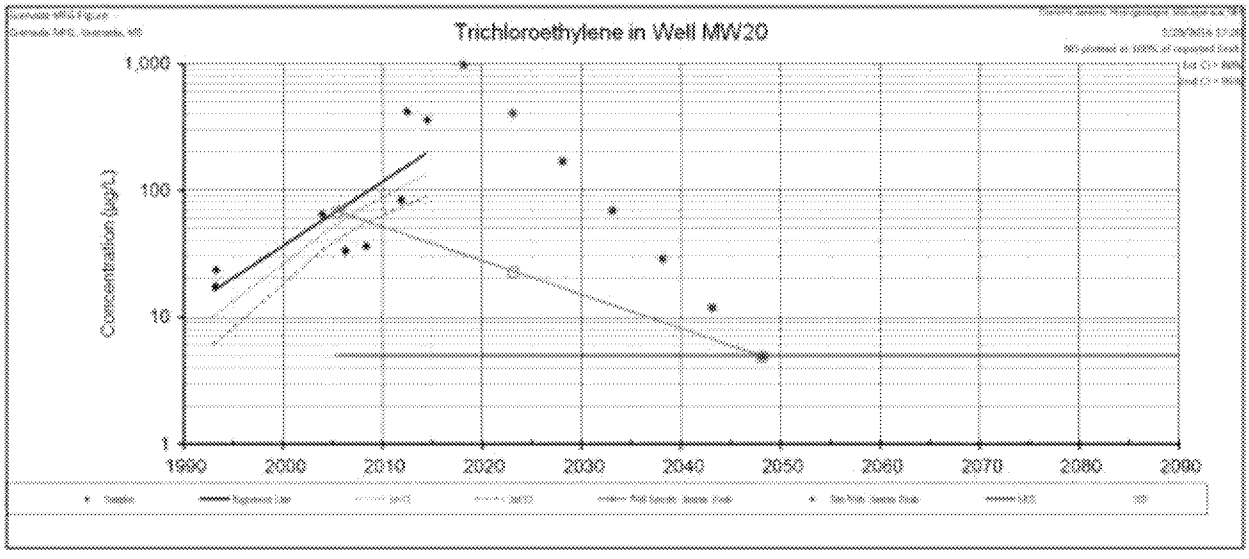

Trichloroethylene in Well MW13
Concentration (µg/L)
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

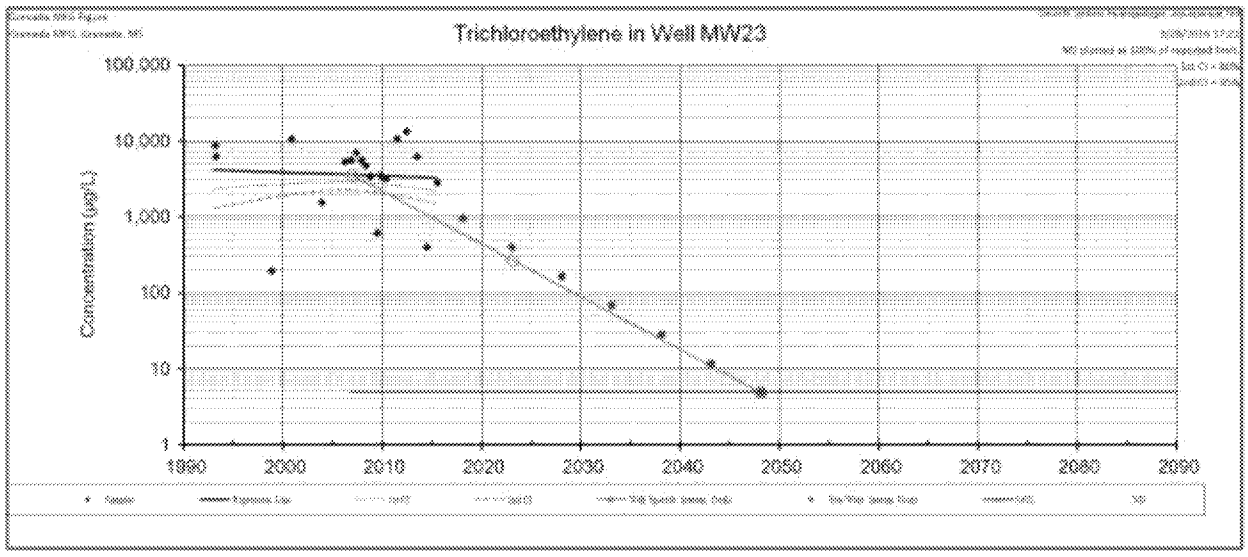

Trichloroethylene in Well MW14
Concentration (µg/L)
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

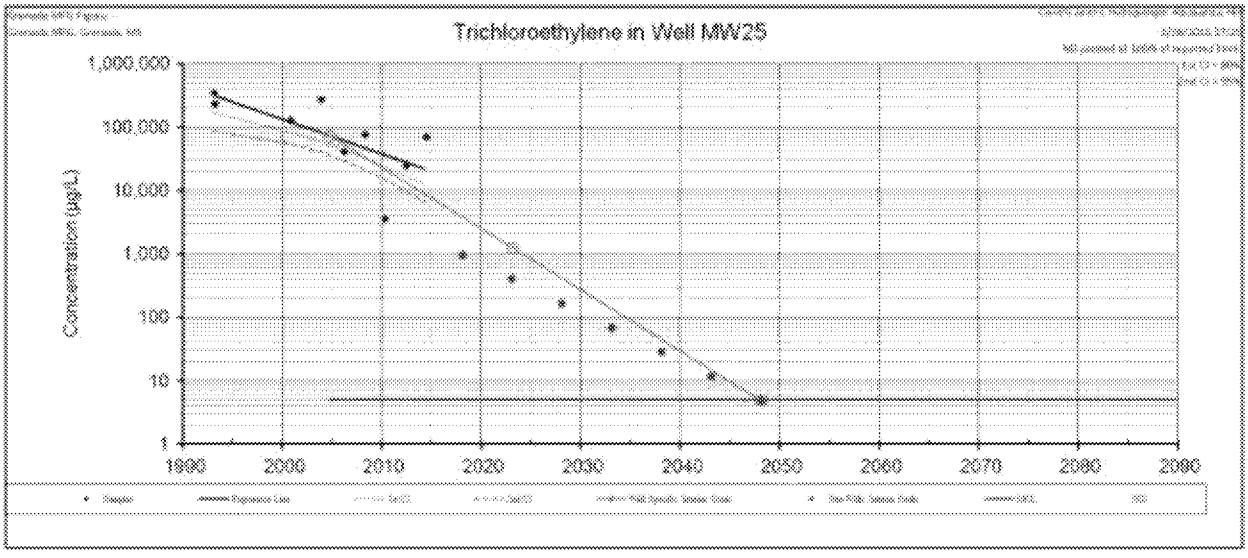

Trichloroethylene in Well MW15
Concentration (µg/L)
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

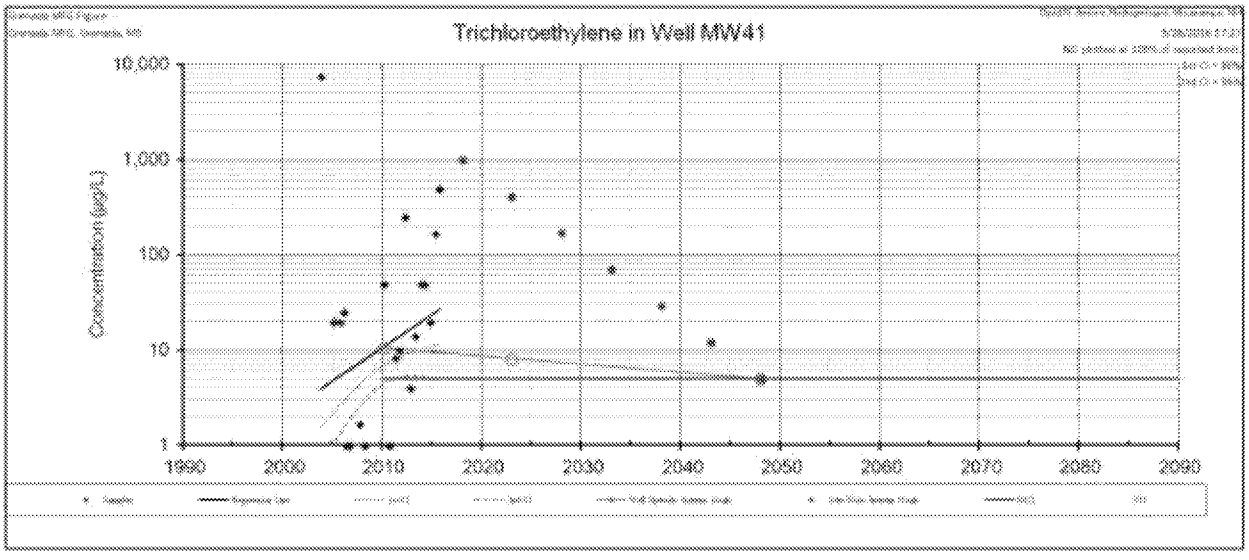

Trichloroethylene in Well MW16
Concentration (µg/L)
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

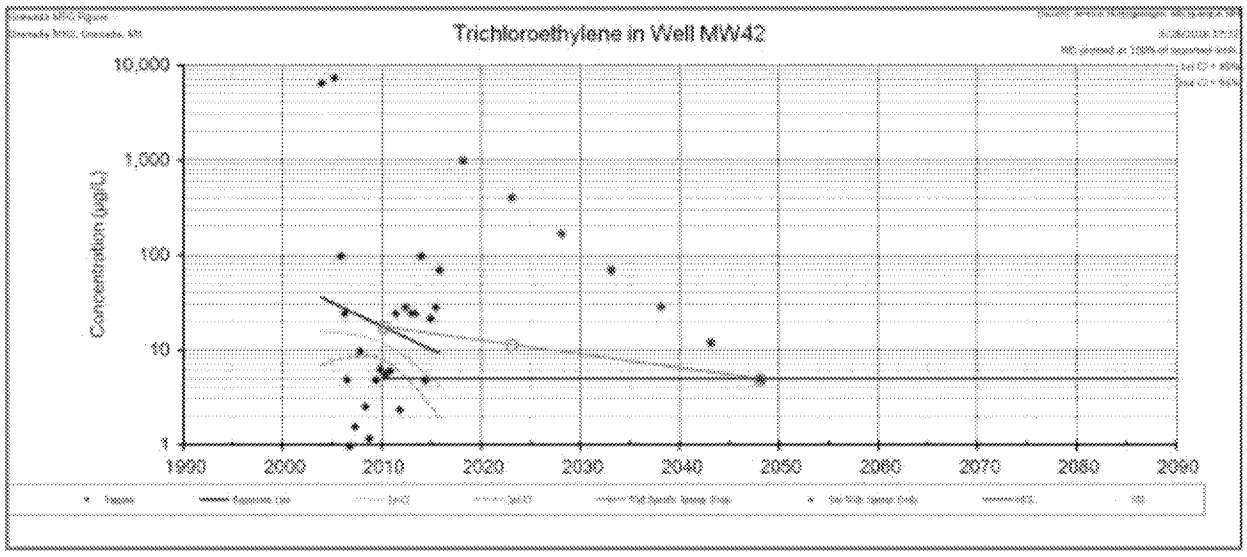

Trichloroethylene in Well MW17
Concentration (µg/L)
100,000
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

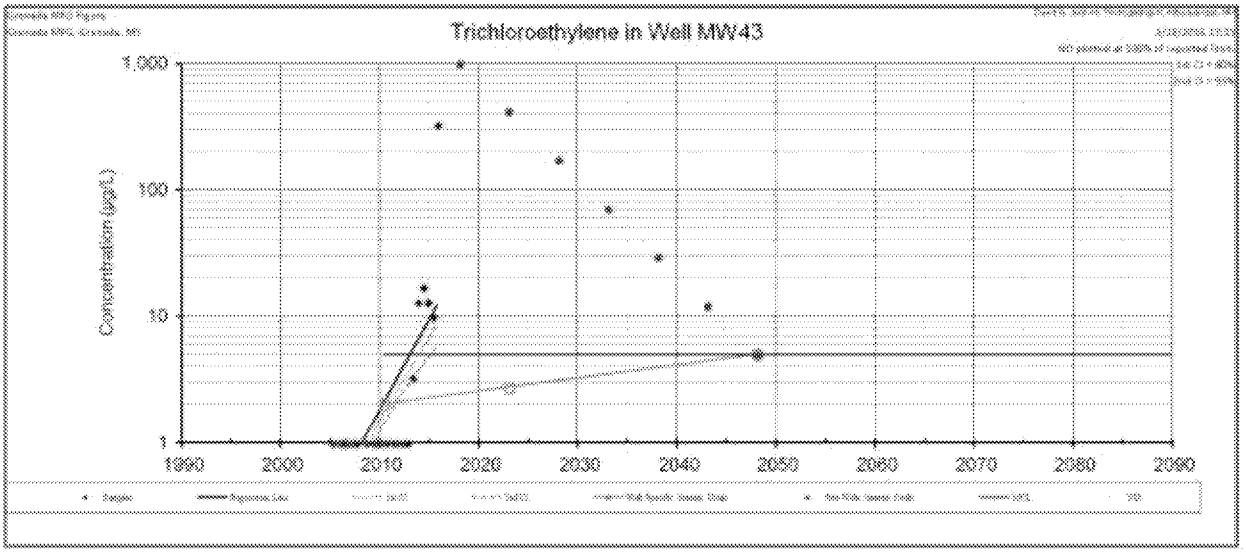

Trichloroethylene in Well MW20
Concentration (µg/L)
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

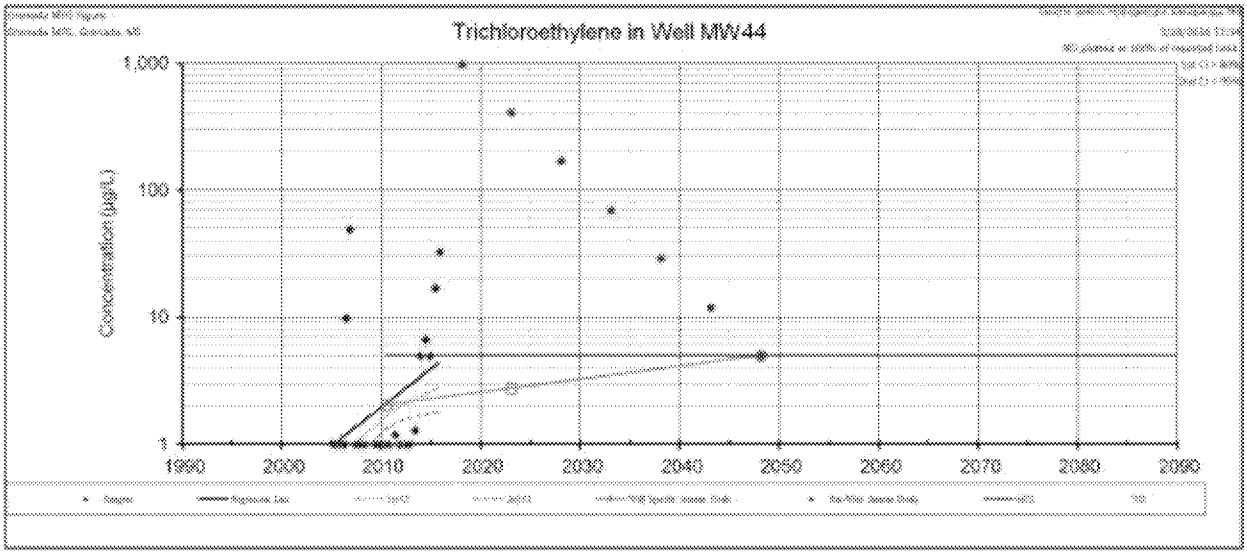

Trichloroethylene in Well MW23
Concentration (µg/L)
100,000
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

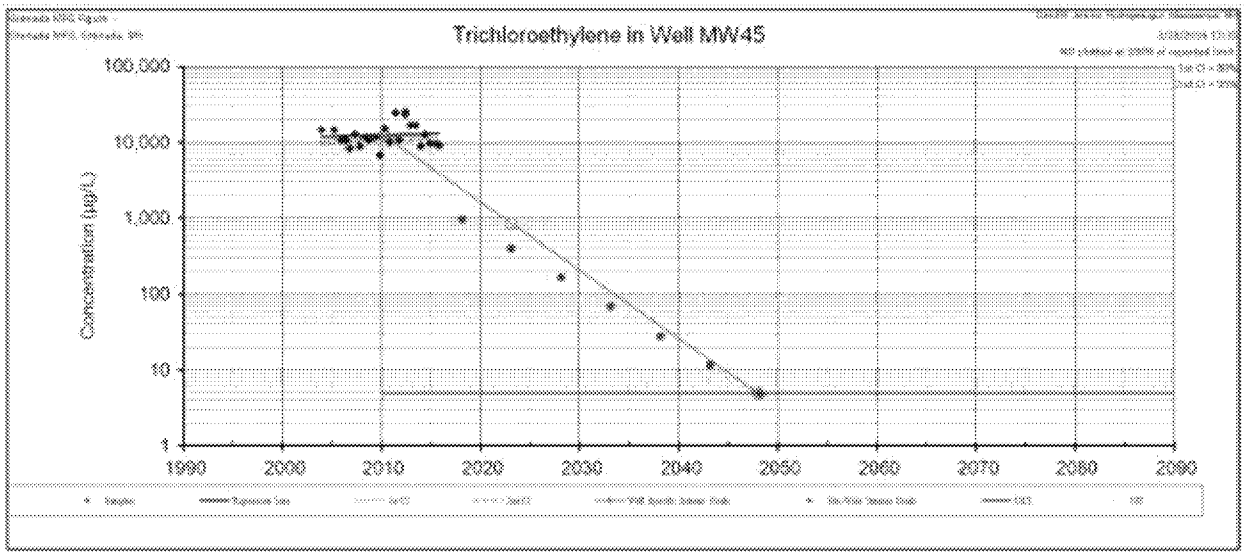

Trichloroethylene in Well MW25
Concentration (µg/L)
1,000,000
100,000
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

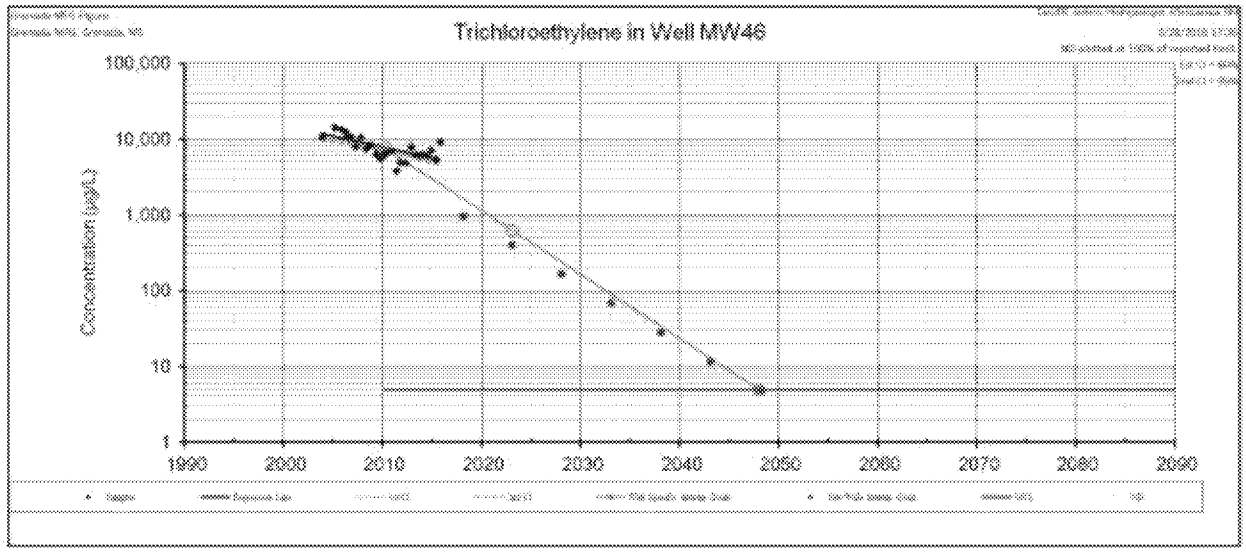

Trichloroethylene in Well MW41
Concentration (µg/L)
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

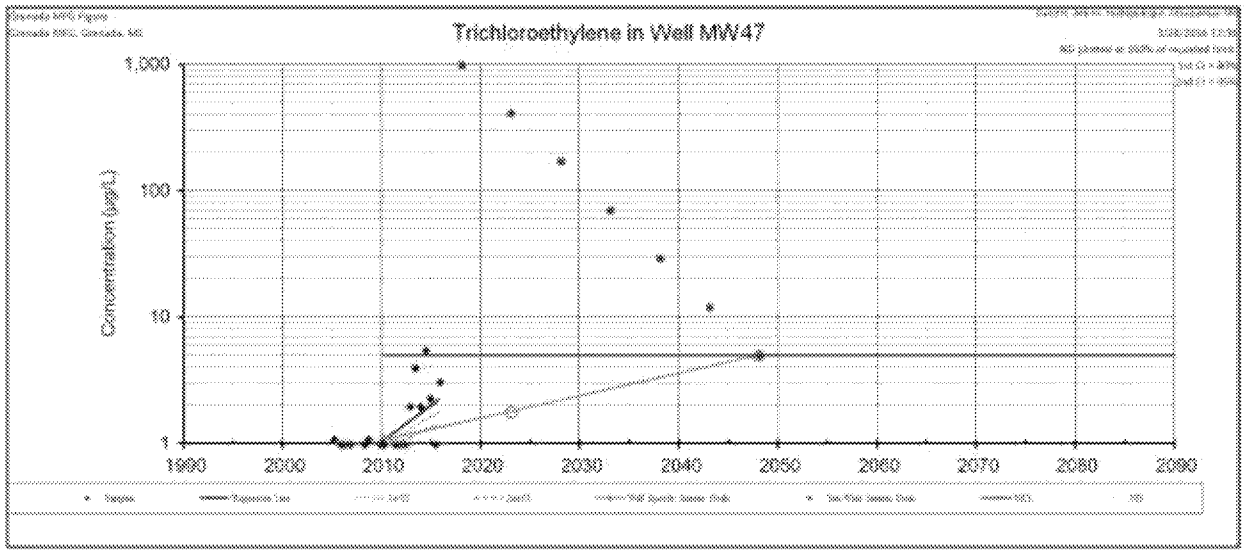

Trichloroethylene in Well MW42
Concentration (µg/L)
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

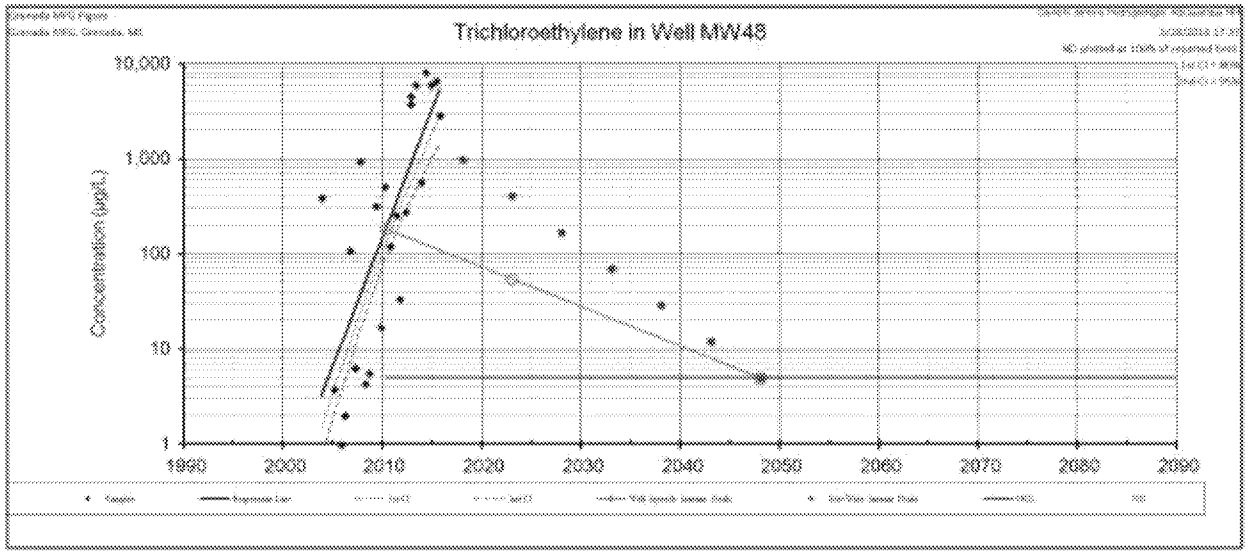

Trichloroethylene in Well MW43
Concentration (µg/L)
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

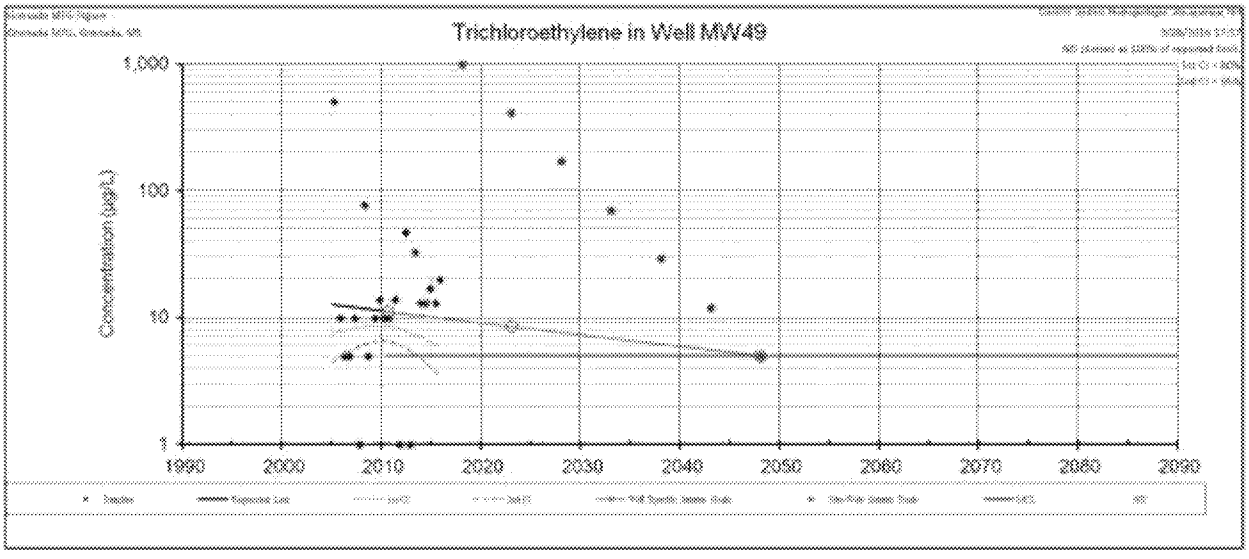

Trichloroethylene in Well MW44
Concentration (µg/L)
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

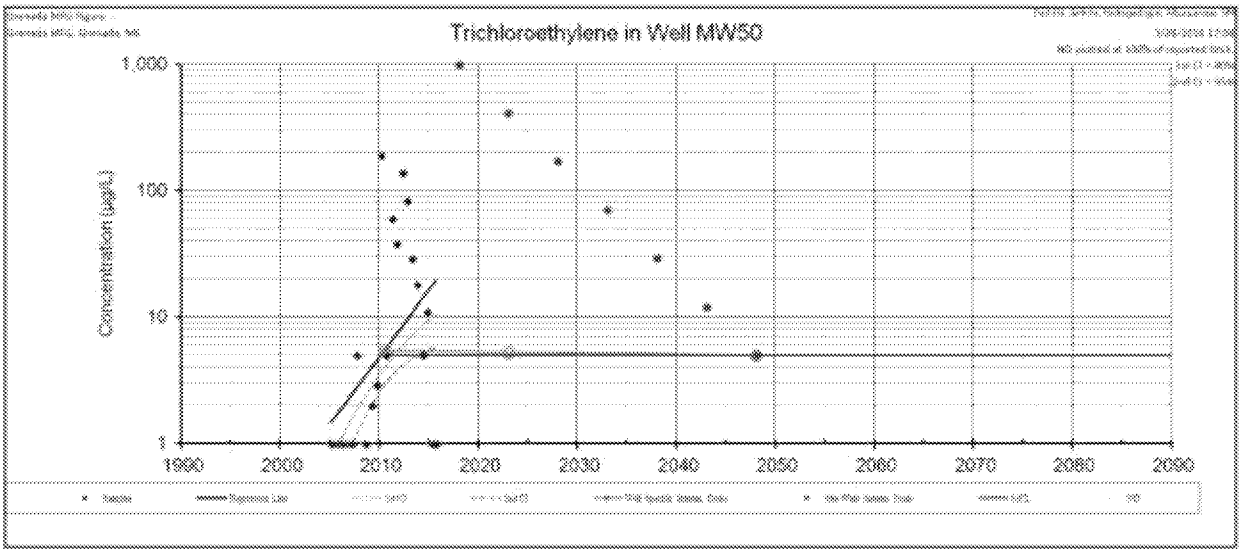

Trichloroethylene in Well MW45
Concentration (µg/L)
100,000
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

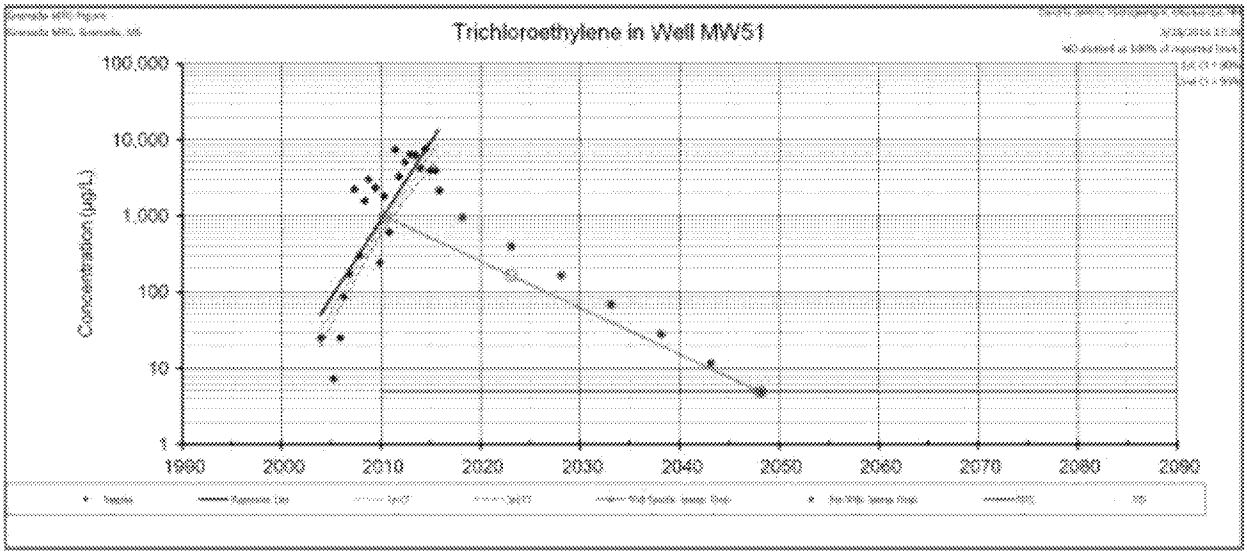

Trichloroethylene in Well MW46
Concentration (µg/L)
100,000
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

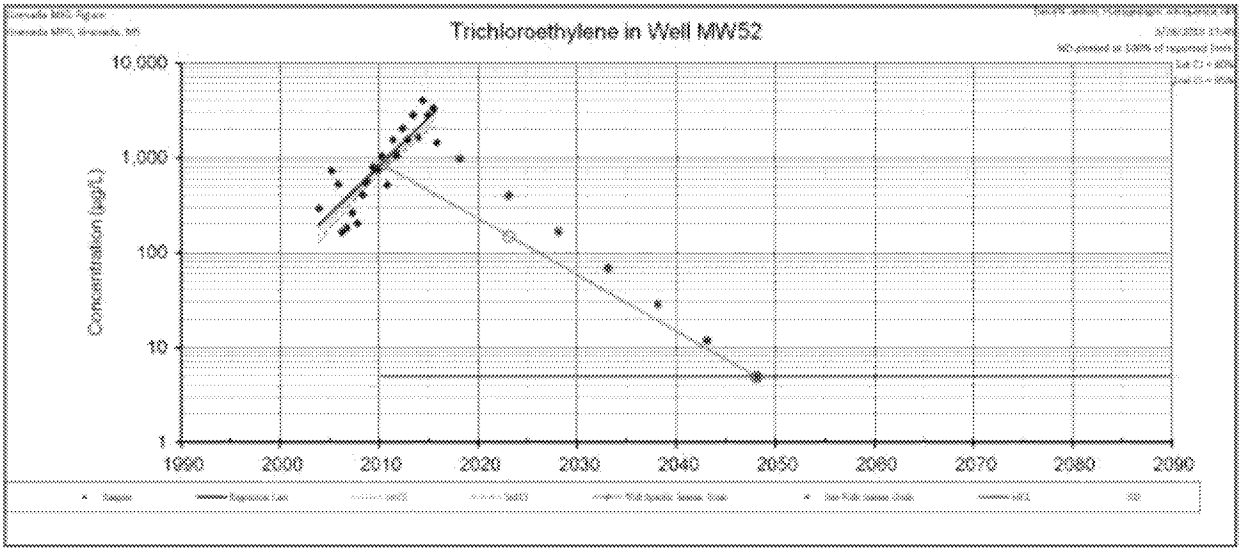

Trichloroethylene in Well MW47
Concentration (µg/L)
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

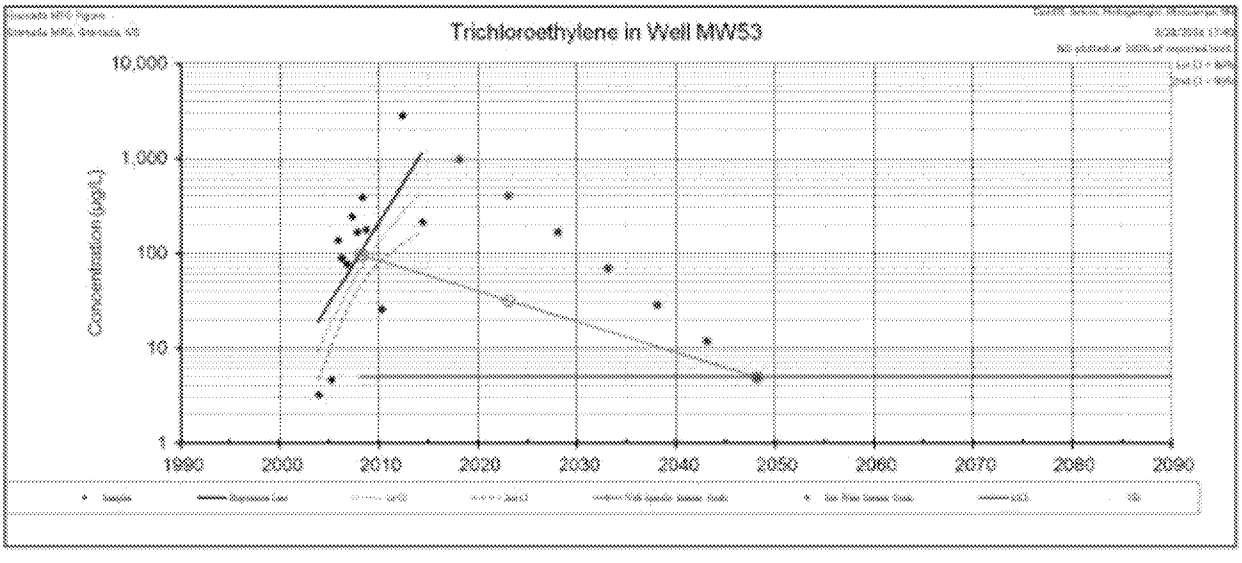

Trichloroethylene in Well MW48
Concentration (µg/L)
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

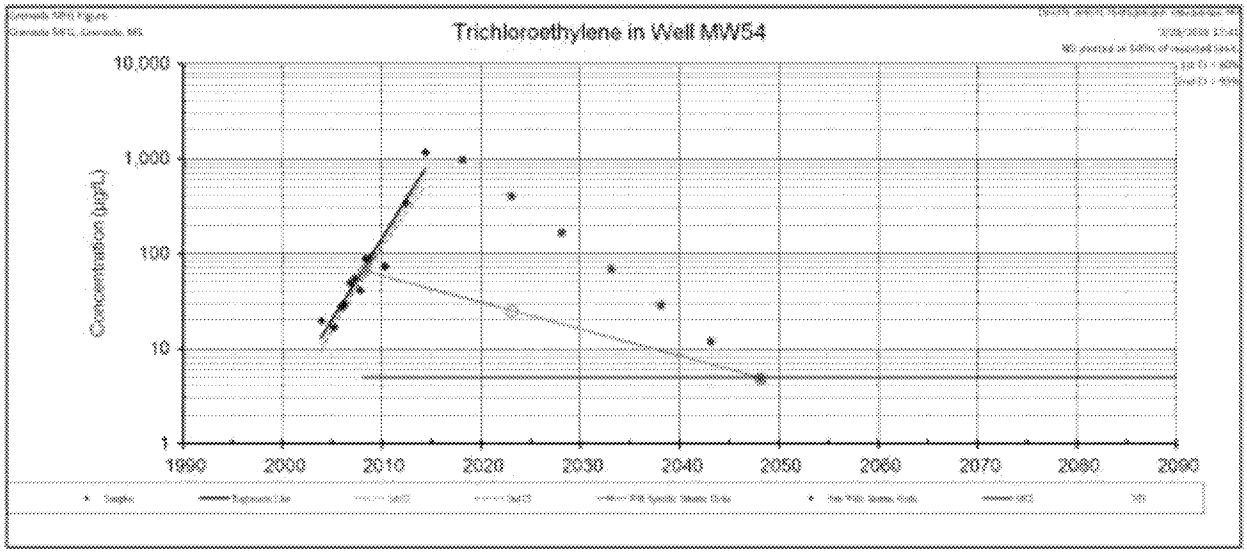

Trichloroethylene in Well MW49
Concentration (µg/L)
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

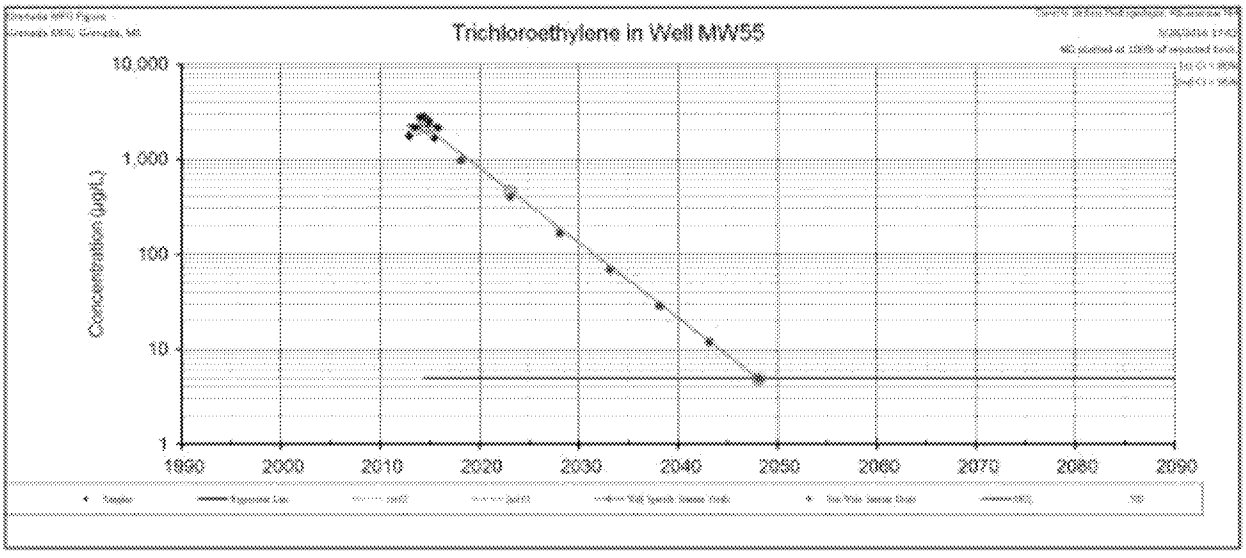

Trichloroethylene in Well MW50
Concentration (µg/L)
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

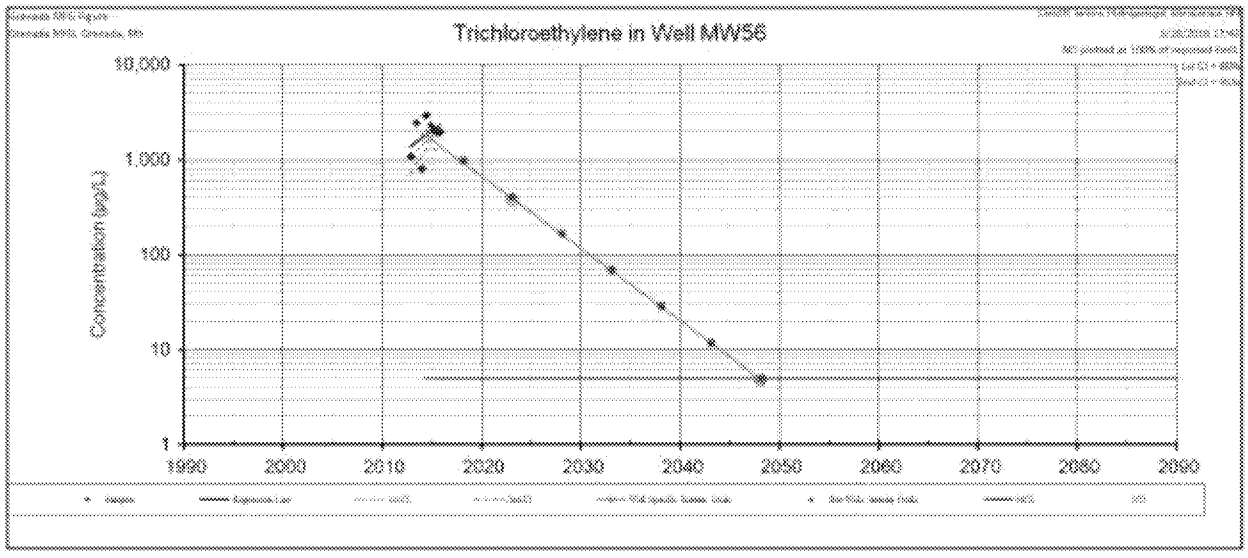

Trichloroethylene in Well MW51
Concentration (µg/L)
100,000
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

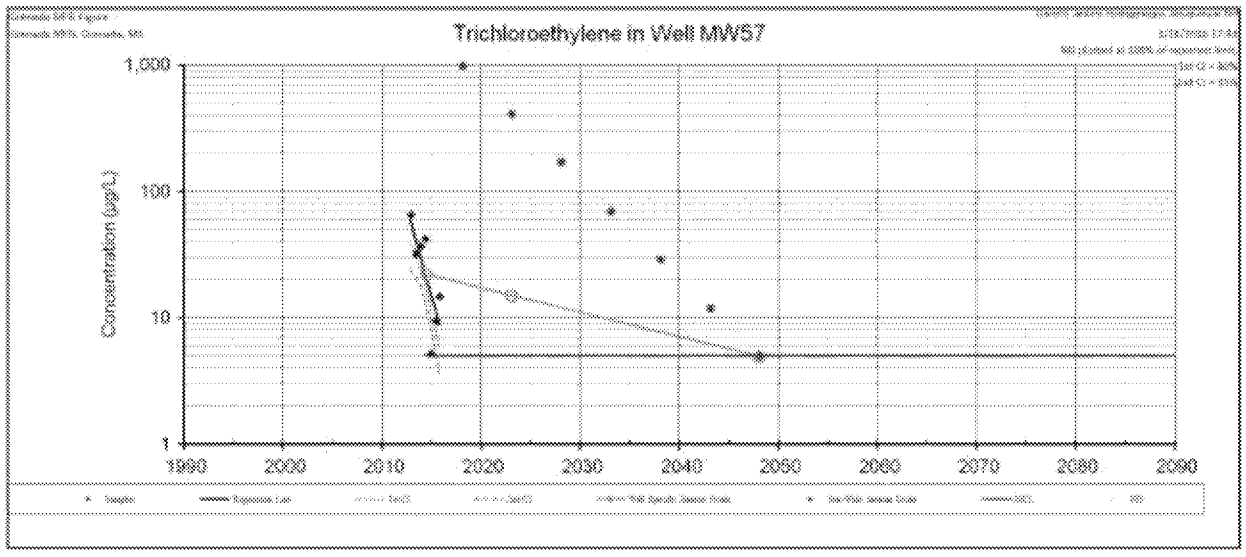

Trichloroethylene in Well MW52
Concentration (µg/L)
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

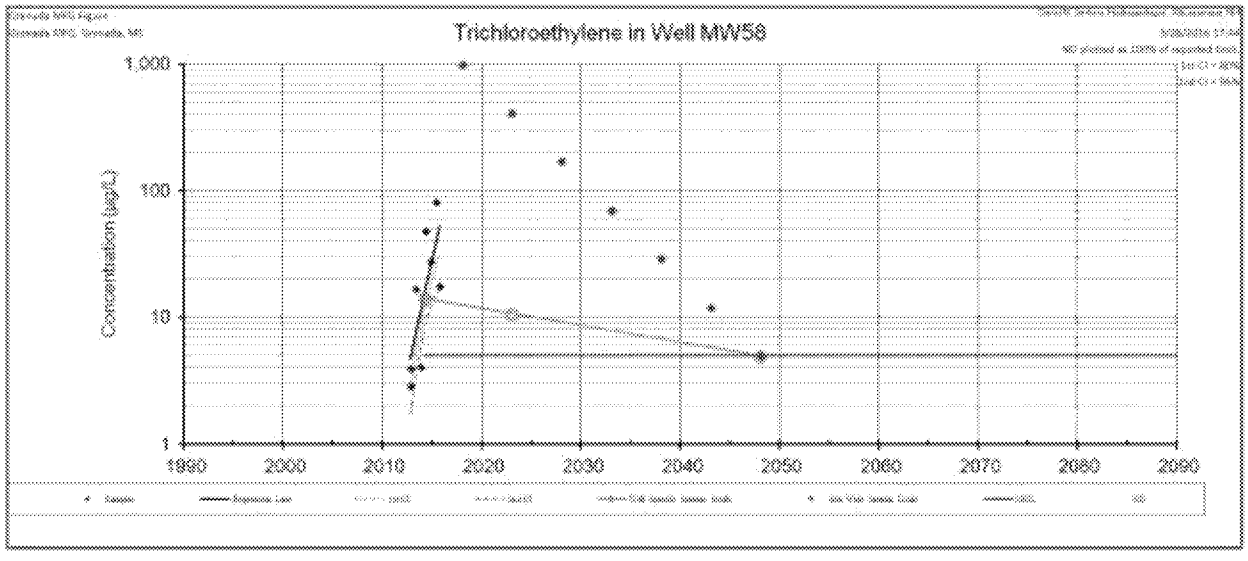

Trichloroethylene in Well MW53
Concentration (µg/L)
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

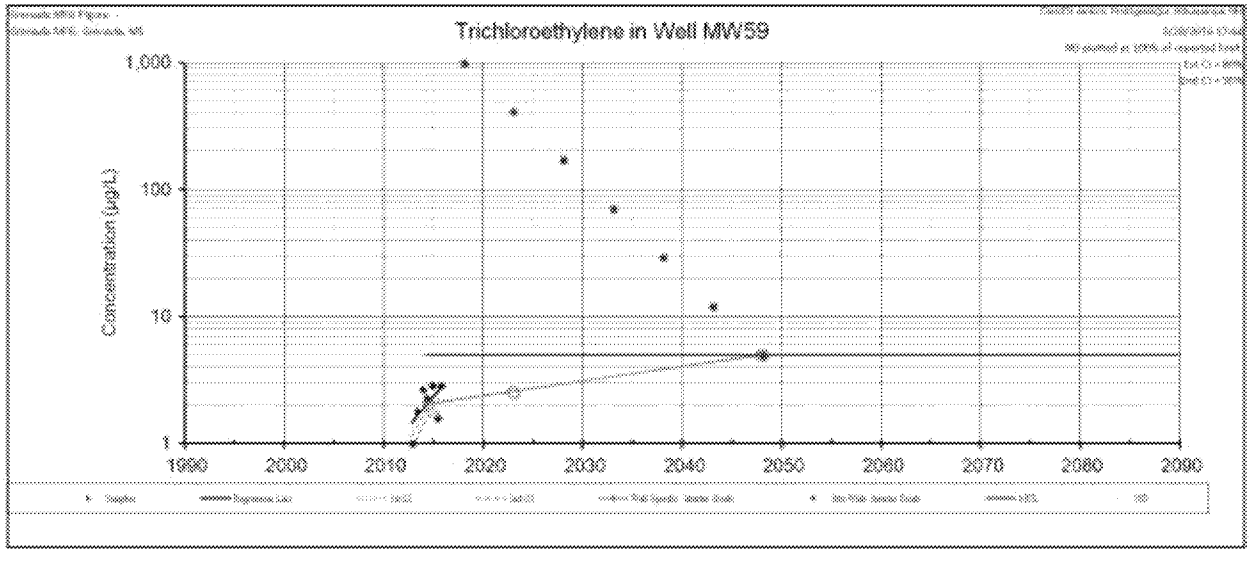

Trichloroethylene in Well MW54
Concentration (µg/L)
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

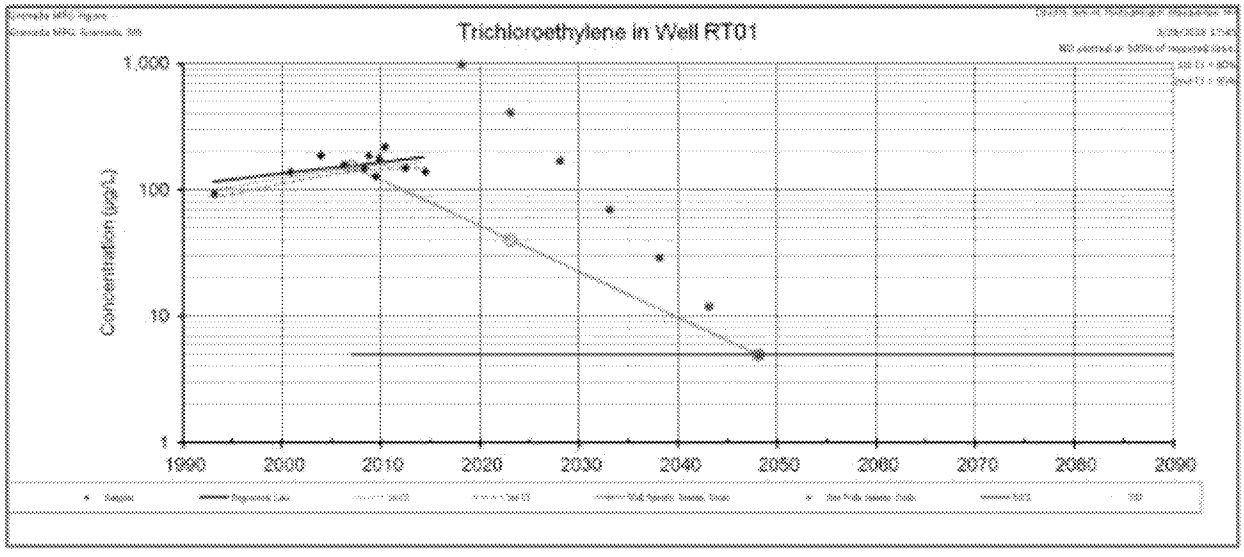

Trichloroethylene in Well MW55
Concentration (µg/L)
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

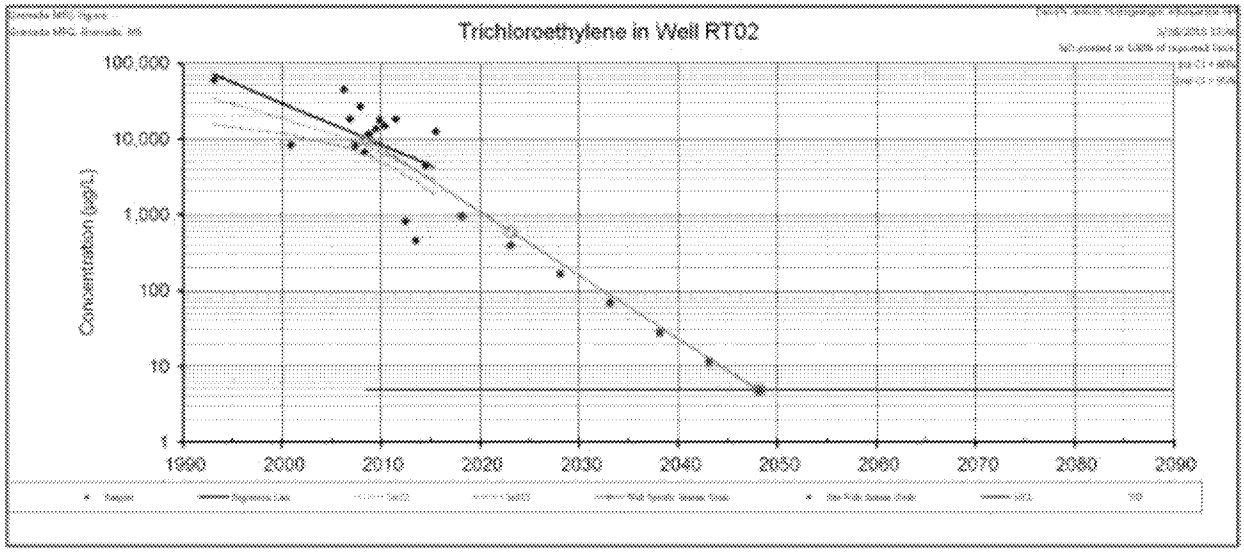

Trichloroethylene in Well MW56
Concentration (µg/L)
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

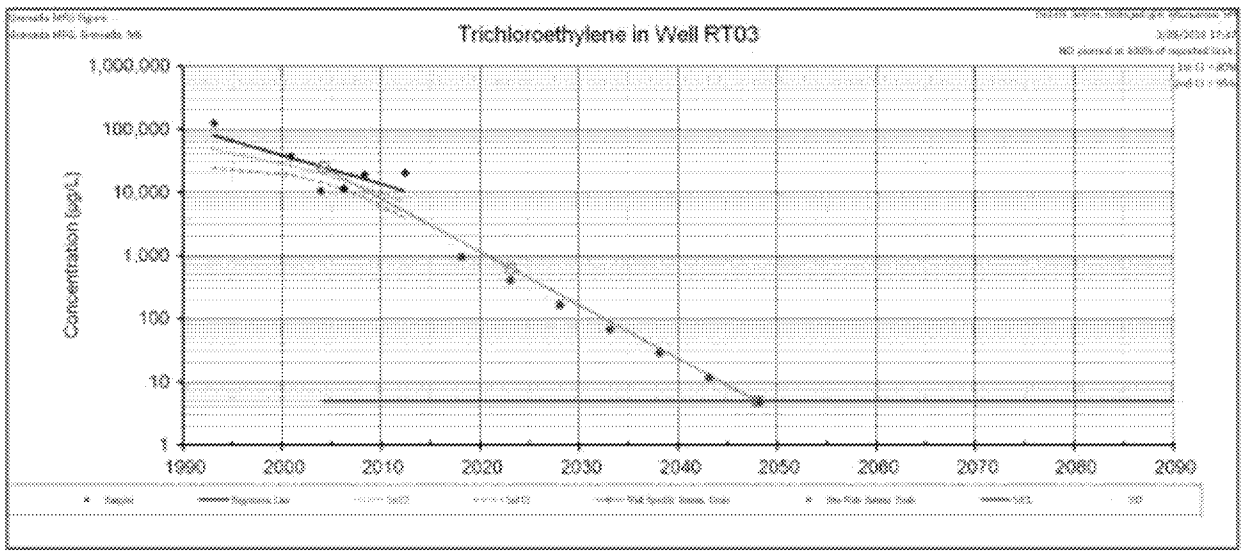

Trichloroethylene in Well MW57
Concentration (µg/L)
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

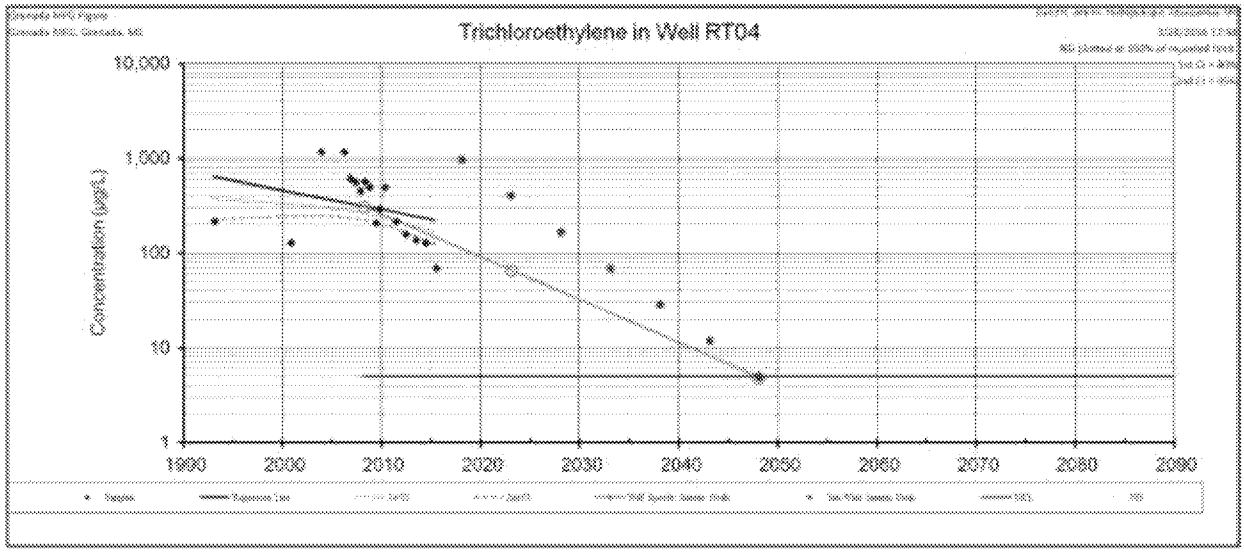

Trichloroethylene in Well MW58
Concentration (µg/L)
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090

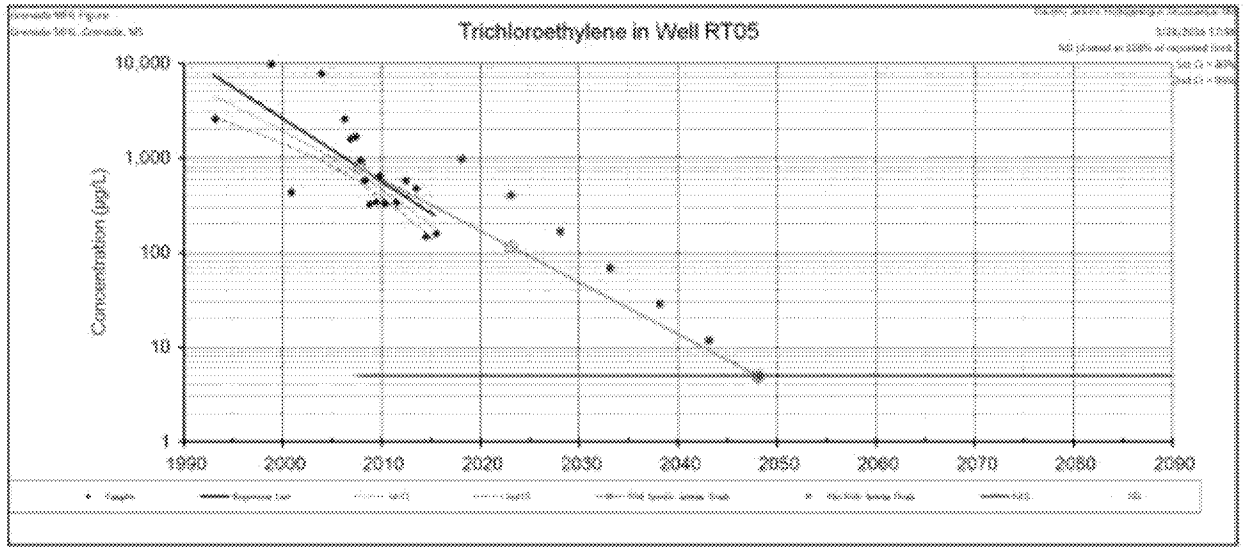

Trichloroethylene in Well MW59
Concentration (µg/L)
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090


Trichloroethylene in Well RT01
Concentration (µg/L)
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090


Trichloroethylene in Well RT02
Concentration (µg/L)
100,000
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090


Trichloroethylene in Well RT03
Concentration (µg/L)
1,000,000
100,000
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090


Trichloroethylene in Well RT04
Concentration (µg/L)
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090


Trichloroethylene in Well RT05
Concentration (µg/L)
10,000
1,000
100
10
1
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090